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Abstract

THE VULCAIN CORE POWER EXPERIMENT

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The Joint Anglo-Belgian Research and Development Programme of the Vulcain Reactor calls for the power experiment of a Vulcain core. This experiment will take place from 1965 to 1968 in the BR3 nuclear power plant at Mol, Belgium, on the site of the Centre d'Etude de l'Energie Nucléaire (C.E.N.).

The Vulcain reactor type is based on the variable moderation principle, using changing mixtures of light and heavy water, to compensate the decreases in reactivity due to fuel depletion. It permits a longer core life and power operation with all shut-off rods out of the core, leading to an improved neutron economy.

After discussing the objectives of the BR3/Vulcain Power Experiment the paper describes the core and the various modifications to be performed to the BR3 primary plant, followed by the proposed commissionning and operating programmes.

The main objectives of the experiment can be summarized as follows : (i) to verify the design parameters of a Vulcain core and its behaviour during the whole core life, (ii) to experiment the fuel behaviour at high burnups, (iii) to test various pieces of equipment.

The core consists of 91 theoretical cells of the same hexagonal cross section. 73 cells each contain one fuel assembly, while the remaining cells each accomodate one Zircaloy tube which may guide a circular flux-trap type absorber rod. The primary D_2O/H_2O mixture rises through the core almost totally in the fuel zone, a small part entering the Zircaloy "moderator" tubes. The fuel assemblies are developed and made half in the U.K. and half in Belgium, each manufacturer starting from UF_6 gas supplied by the U.K.A.E.A.

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The modifications to the BR3 plant will take place during the latter part of 1964, after the first pressurized water core has been used up. They consist mainly in the adaptation of (i) the BR3 reactor vessel to the use of a Vulcain core and of (ii) the primary plant to the use of a D_2O/H_2O mixture.

The internal equipment of the reactor vessel is completely replaced. Ten absorbing rods are operated by the existing magnetic jack mechanisms located on the vessel lid, thus requiring special eccentric holding devices to connect eight of the rods which are offset. Four prototypes of hydraulic mechanisms will also be experimented. Extensive in-pile instrumentation is provided : (i) the flux wires slide inside thimbles attached to two vacated rod mechanism penetrations in the vessel lid (ii) the thermocouples and fission chambers are immersed and connected through a "collar" which is added between the vessel flanges.

The main problem concerning the primary systems is due to the use of a D_2O/H_2O mixture. It is indeed intended to operate BR3, which was originally designed as a H_2O plant, up to 2000 psia (140 kg/cm^2) and 500°F (260°C) which is higher than any other existing D_2O reactor. Extensive tests have therefore been performed on the BR3 plant to trace the leaks and determine their amount, in order to study the improvements to be effected to the circuits from that point of view.

The operating programme will comprise many cycling and perturbation tests to (i) subject the fuel to conditions similar to those encountered in a land based or ship propulsion unit, and (ii) obtain sufficient experimental data to arrive at a satisfactory mathematical model of the core behaviour. Various reactor control and water treatment methods will also be experimented, and the core will be operated at various pressures, down to the lowest pressure compatible with safe operation.